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GENERAL HYGIENIC, PHYSIOLOGICAL AND PSYCHOLOGICAL
PRINCIPLES AND DIRECTIVES FOR THE INTRODUCTION
OF MECHANIZATION AND AUTOMATION

- CZECHOSLOVAKIA -

by Jan Roubal

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GENERAL HYGIENIC, PHYSIOLOGICAL AND PSYCHOLOGICAL
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OF MECHANIZATION AND AUTOMATION

- CZECHOSLOVAKIA -

[Following is a translation of an article by Jan Roubal
in the Czech-language periodical Ceskoslovenska Hygiena
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321-330.]

A. The XIth Conference of the KSC (Komunisticka Strana
Ceskoslovenska-Communist Party of Czechoslovakia) has brought the
questions dealing with the increase in the productivity of labor
through technical development and modernization of production
into the foreground, especially through the utilization of chem-
istry, mechanization and automation. These will provide important
means for the improvement in the standard of living and for the
completion of the build-up of socialism.

It is necessary to emphasize that from technical develop-
ment and from the very principles of socialistic society, there
emanates a demand that first consideration be given to man as the
agent responsible for the operation of the new machines, techno-
logical processes and whole production lines, and in the technical
and organizational solution of these problems.

Technical development is designed not only to contribute to
the insurance of a higher standard of living through increased
consumption level of the whole society, but also to solve, by
mechanization and automation, questions pertaining to health pro-
tective among the workers against the various harmful factors con-
nected with production, especially in those areas where effective
health protection cannot be guaranteed by other means, e.g., in the
development of nuclear energy.

The savings in communal labor and the increase in produc-
tivity brought about by the introduction of mechanization and
automation will also make possible substantial and quicker reduc-
tion in the work day, especially in production lines involving
factors detrimental to the health of the workers. This improvement

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in the conditions of work will lead to the improvement of cultural standards of labor and to a substantial reduction in the morbidity and invalidism caused by work conditions.

Besides the tangible questions concerning health protection among the workers, mechanization and automation will create many problems involving the medical point of view: These are, e.g., extension of the productive age connected with the physiological questions of work at advanced age, the problem of reassignment and correct distribution of persons belonging to the various age groups, the problem of qualification and permanent supplementary training at various ages, questions connected with the insurance of healthy somatic development of the people and with the insurance of the full development of their capabilities.

With all this is also connected the problem of correct utilization of the increased free time. It is necessary to insure correct reconstitution of work forces in the changed conditions of work created by the character of mechanization and automation.

1. On the other hand, it is necessary to emphasize that incorrectly instituted mechanization and automation or their incorrect and unsuitable introduction could cause many health difficulties in the broad sense of the word. It is therefore necessary to accumulate all the experiences from automatized or mechanized production lines, especially from the experimental and developmental work-shops, and to take timely steps for the effective insurance of the protection of the workers health against the harmful effects of mechanized or automatized production and related processes. Special attention must be given to production lines in which mechanization and automation is only partially introduced.

In the current technical development of mechanizing means we frequently fail to consider the type and manner of human labor involved in the operation of these means. Thus, e.g., many mining machines and instruments such as combines and drilling outfits caused an increase in the dust and noise level at the place of work and an extensive exposure of the workers to tremors. In some cases there also occurred an increase in the physical effort needed and an enforced speed-up in the work rhythm in the related manual processes. As an example, we present the following: The introduction of a non-irrigated, high-speed-cutter combine with an uninterrupted cycle caused increase in dust production, reduced the possibility of injecting the layer with pressurized water, increased the noise level of the work area, and forced the rest of the mining crew to increase their work tempo, especially in connection with support and prop construction.

2. The progress of mechanization and automation in our economy is not only a question of a change in technical equipment, but also a question of a change in the work activity of the men appointed to handle this equipment. The successful performance of new tasks places new types of demands on the worker.

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Mechanized work generally reduces the physical demands and increases the mental demands. In his work movements, the worker often has to adapt himself to the structure of the machine, and the work speed is also often dictated by the machine. Mechanized work causes increase in the division of individual work tasks as can be clearly seen in serialized production. Extraordinary demands are often made in relation to highly specialized and exactly executed skills. From this specialization there emanates the loss of the total picture of the work process and its goals from both the technical and the socio-economical viewpoint. This is very serious in a socialistic system. Because of this, it is especially necessary, from the point of view of psychology, to develop and deepen the intensive training and education of the employees parallel to the introduction of mechanization and involving both technical and political knowledge.

Technical means developed relatively independently without a continuous consideration of the worker, often places such physical and mental burdens on men that they can be operated successfully only by a selected portion of the workers, e.g., when the serial shoe production process was based on the output and efficiency of young men. In some specialized activities it appears desirable to select workers who are capable of carrying them out securely and reliably without mental and physical overloading and without endangering themselves, their fellow workers and the equipment entrusted to them.

3. A special problem is produced by specialities where mechanization is just being introduced or where, due to economical or technical reasons, only partial mechanization is possible at this time. Here it is very easy to cause disharmony between the mechanized component and the remaining non-mechanized production processes. This can cause overloading of the workers in the non-mechanized components of the production process, both in the sense of work speed and mental strain. In these cases, the solution depends largely on the correct organization of labor, on the selection, placement, training and retraining and supplementary training of the workers involved.

4. In connection with the development of mechanization and automation, it will also be necessary to pay greater attention to the questions of physical education than heretofore. The goal of physical education will, in this case, be not only the insurance of healthy development of the organism in general, but also the training in the proper movements necessary to the new type of work and in the conduct of compensatory (restitutional) physical exercises according to the individual work load.

5. From all this, we can see that, even in mechanized and automatized production, man will remain the most important factor since he regulates the production. In the introduction of mechanization and in the development of automation, it will therefore

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be necessary to fulfill all the principles insuring the workers health protection and the full development of his work capabilities. Also, in the development of mechanization and automation, it is necessary to realize all the prescribed hygienic and security regulations, and to remember to systematically utilize the newest findings in hygiene, physiology and psychology of labor. It is necessary to emphasize, once more, that mechanization and automation must be sufficiently oriented toward the removal of harmful factors in the production processes, toward the removal of the worker from sources of harmful materials, toward the removal of heavy and one-sided physical effort, monotony and onesided loads. The work regimen must also be properly organized for each day according to physiological and psychological principles.

Special attention should be given to the arrangement and decoration of the work area. It is necessary to have an esthetic interest, not only in regard to the technical means, but also in regard to the entire work environment.

6. One of the factors which have an important part in the potential production of harmful effects or which are a direct cause of these effects is the incorrect assignment of work norms due to utilization of time measuring data concerning the partial tasks of the worker in the production process. Whenever no consideration is given to the principles of the components of these tasks, norm estimation leads to false assignments and to incorrect measurement of a "technically justified norm." The most serious aspect of this is the fact that in the determination of the output of a definite number of individuals performing a given task, no consideration is given to the actual load to which each man is exposed under these conditions. This is the reason why in some cases of recent mechanization, the worker expends more muscle and mental energy to fulfill his norm than he did when the same work was done manually. These deficiencies can be seen especially in the areas where the normalized work of the collective is only partially mechanized. In mining, e.g., the norm is often affected by the output of the machine regardless of the effort and enforced speed in the areas of related manual labor (prop construction and loading are adapted to the output of the machine). It is necessary to give some thought to these circumstances: It is not impossible that this fact is one of the main reasons for the conservative view taken by some of the workers in regard to introduction of new technology into their field. It is obvious that norms must be based not only on technology according to the output of the machine, but that they must also consider the demands determined by the physiology of the worker.

7. Under certain circumstances, mechanization can also unfavorably affect the environment of the factories and therefore, also the life environment of the workers. We all know, e.g., the

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harmful effects of such procedures in which new technological processes and even whole factories were placed into production without any consideration of the questions of hygienic security of the surrounding areas, e.g., processes involving the burning of low grade fuels in large power plants or the production of aluminum.

8. It is necessary to state that in some cases, however, the collaboration of the health workers with the designers and technologists brought about some highly favorable results. Let us examine a few: In the construction of agricultural machinery, in some cases, the demands of the medical workers were obeyed and, e.g., the mobile platform for the sorting of beets, the tractor seat and the hop picking machines were properly designed. Similar positive results were also obtained in the technico-esthetical arrangement of the mechanization equipment and in the form finishing of various instruments. Positive results were obtained through the harmonization of the physiological, hygienic, psychological and esthetic demands.

B. The health problems of mechanization differ partially from the health problems of automation. This is because mechanization means are always operated directly by a worker who must be continuously present. Because of this, we will examine in the following paragraphs, first, the questions of mechanization of production processes and then the problems pertaining to automation. However, we do not want to say that some points are common to both mechanization and automation.

1. Problems of Mechanization of the Production Processes

a. In our production there still exist many important hygienic factors which endanger the health of the workers to a lesser or greater degree. We have not, as yet, sufficiently reduced the physical effort involved in the individual work tasks in some of the production processes.

b. Mechanization can therefore be a great contribution from the point of hygiene and physiology of labor.

Let us examine several examples: Mechanical loading of smelting ovens and electrical ovens by a loading derrick has substantially reduced the effect of searing heat on the smelter who is sufficiently removed from the heat source and is protected by a shield. Mechanization of metal rolling and pressing processes has also contributed to the decrease in the heat load affecting the workers. Correct air-technological solution of material transportation, mechanized filling of sacks with dust materials and automatic weighing and dose determination have contributed to the reduction of dust particles in the air of the work area. Also, in the chemical industry the purity of the air often depends on the degree of mechanization (the same is true of automation) because only a mechanized process makes proper hermetization possible.

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c. From this ensues the necessity of determining the time priorities in the development of mechanization, e.g., to first mechanize those processes involving the production of toxic materials, excessive dust, unfavorable microclimatic conditions, shocks and excessive noise, the risk of ionizing radiation and excessive heavy physical effort.

d. However, we must understand that absolute exclusion of harmful factors from the mechanized processes is not quite possible. Because of this, it is necessary to evaluate the construction and organization and inclusion of mechanization in the production process from the point of hygiene. It is necessary to locate the sources of hygienically detrimental factors in each mechanized process, to measure the amount and degree of occurrence of these factors during each shift, and to evaluate the relationship between them and the worker. The means of mechanization often increase the intensity of production. This also causes a basic increase in the hygienically important factors and results in a disregard for the hygienically acceptable values concerning the harmful factors within work environment.

Thus, in the introduction of mechanization:

(1) There occurs a frequent increase in the harmful factors released because of the substantial increase in the volume of production. If these sources of harmful factors are not sealed off, exhausted, watered or somehow neutralized in somehow there must develop an increase in the concentration of the harmful substances in the air of the work area.

(2) There occurs an accumulation of various sources producing various harmful factors at the same time and place. In this it is difficult to insure the purification of the air in the work area by the current methods of health technology. Thus, production lines which involve simultaneous production of dust and various vapors of different physical and chemical properties cannot be neutralized by a single type of exhaust tubing.

(3) We cannot utilize several tried exhausting techniques because of the movement of the machinery, conveyor belts, etc.

It is obvious that in the construction and introduction of mechanizing machinery, it is necessary to check the hygienic characteristics of the area in which any worker will operate the machinery, and to find new construction methods which would satisfactorily guarantee the hygiene of the work environment.

c. Due to methodology it seems effective to divide mechanization machinery as follows:

(1) Stable is that which is installed at a definite place. These are machines in chemical smelting and machinery production.

(2) Mobile is that which moves from place to place during the work, e.g., agricultural machinery. These involve still other health considerations in relation to vibration, position of the

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body during the performance of a given task, increase in the degree of alertness and concentration necessary in the performance of a task while moving over land, etc.

f. One of the mechanization means is the means of transportation in the production process which has its own related medical and psychological problems. These are, e.g., production lines in which the part worked on is moved from one work area to another by means of a conveyor belt. These lines are being widely introduced into industry because modern production is becoming more and more serialized. Until these lines are fully automatized, we will have to deal with the following hygienic problems:

(1) Division of work tasks in the production line does not always correspond to the principles of physiology of labor. There occur monotony and extraordinary loading of the senses and lesser muscular groups which lead to early fatigue and symptoms of tiredness. Also, the position of the body during the performance of the task is not always suitable.

(2) Speed of the products on the line is not always in harmony with the physiological daily work curve. For instance, the physiologically correct division of work performance in every work hour is often neglected as well as the correct arrangement of work breaks. The speed of the belt often cannot be regulated and changes in the performance in the individual days and weeks are disregarded.

(3) At the production lines there are many sources of harmful materials which makes their neutralization at the source difficult.

(4) Organization of work in associated and supplementary production areas is not always harmonized with the output of the production line.

(5) In production lines we often see great density in the number of workers. Because of this, we must select a correct type of building and the work areas in general.

(6) Production lines are not always constructed and organized so that the worker has sufficient and proper accident protection.

(7) Insufficient care is given to the purification of the exhaust materials before they are released into the surrounding atmosphere. Waste liquids are also not always properly purified and hygienically perfect, disposal of solid wastes is often neglected.

We can see that it is necessary to set up the production lines not only from the point of view of economy of production, but also from the point of the principles of hygiene, physiology and psychology of labor.

2. Problems in automation of production processes.

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a. Problems of automation can be divided into two groups. If we are dealing with automation of only the individual work processes, e.g., processing machines, then we can apply the principles mentioned in relation to mechanization. If we are dealing with automatized work-shops located in mechanized production, then, the demands are generally the same as those involved in production lines. However, entirely different are the problems involved in fully automatized production. This differs from mechanized production by the fact that the worker is present only in a supervisory capacity, as a maintenance mechanic, a setter, etc. If the production involves the risk of harmful materials, only a small number of workers are exposed to the effects of the harmful factor and health protection is often insured by personal protective aids or by little oases with pure air supply, etc. Because of this, in automatized production it will be favorable to insure the control of the production medium with the aid of automatic analysers or measuring instruments depending on the character of the dangerous factor.

b. As far as automatized machines and some automatized lines are concerned, we can see various sources of hygienically important factors. Let us examine several examples: Automatized machines often have much larger numbers of movable parts and areas, many of which are pneumatically controlled. This causes a substantial increase in the noise level in the work environment.

c. It is also necessary to consider that in the automatized production process the air in the work area and the surrounding areas will be exposed to various harmful factors. Because of this, it is necessary to project automatic purification of exhausted gases, vapors, drained waste liquids, etc.

d. Automation of production removes the direct contact of the worker with production. However, should it be necessary to construct work stations in dangerous production lines for the supervision of the course of production, these separate work stations should be supplied with fresh air. In case of failure it is necessary to provide for auxiliary ventilation which would insure hygienically perfect work environment for the maintenance and setter personnel who occasionally work in closed areas of the automatized line in production processes involving an element of risk.

e. It has been stated above that automation of production removes the worker from the areas in which the purpose of the individual work task is obviously apparent. This is an extremely important psychological circumstance. In the organization of automatized production, it is therefore necessary to remember to insure a high degree of informedness of every worker concerning the production process as a whole. The worker must not feel that he is just another machine. Mechanization means semi-automats and

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automats must be operated by well-trained personnel who must also be trained in the problems of safety and labor hygiene. Through proper training, the worker will become interested in the total production process and he will not develop a sense of monotony in his work task.

f. From the point of view of demands on the human organism, automation does not merely mean a gradation of mechanization. In production technology it represents a qualitative jump ahead. Today deficient experience prevents us from determining the results of automation in regard to the demands made on the worker. This makes it even more important for these questions to be systematically examined. It is necessary to carry out all necessary steps so that the introduction of automatized production in our country would not be hindered by insufficient preparation of the workers or be connected with undesirable consequences in regard to the health of the worker.

g. Automatized production also makes even higher demands on mental alertness, requires speedy reactions to signals as well as substantially higher analytical and synthetic ability in mental work. Because of this, it is necessary to give attention to the questions of the physiology of higher nervous activity, and the psychology of work emanating from the manner of construction and operation of panels, indicators and control boards. Here it is important to give proper attention to the proper understanding and legibility of signals, the most suitable marking of the regulating elements by normalized designation markings, colors, shapes, etc. Especially important is the insurance of the understanding of the functional relationships of the indicators and the control instruments. At such work areas it is necessary to provide suitable work environment by correct lighting, color arrangements, physiologically correct microclimatic conditions, removal of noise, etc. All this makes concentrated and accurate observations easier and provides for proper operation of the control panels and boards.

h. From the psychological point of view the most important is the fact that automatized work is not immediate labor. Between the man and the product there are not only tools or relatively simple machinery, but complex automatic equipment, the output and product of which is far removed from the actual activity of the personnel operating this automatic equipment. This makes it necessary that every worker have a full knowledge of the total production process in which his specific task is included, a good understanding of the total economical situation of the factory, and that he take an active interest in the economic goals pursued by his factory at any given time.

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Changes in production will bring about an increase in the demands made on sensory and nervous activity, on specialized qualifications, and on the character traits of the workers, especially discipline and sense of responsibility. If there should occur discrepancies between the demands made on the worker through the output and his capabilities, his sensory and mental effort will be increased and this will result in damage to the nervous system due to unaccustomed strain and nervous overactivity. Such overstrain remains for a long time without symptoms, but can be suddenly exhibited without preceding prodromal signs. We have many good methods for the estimation of muscle fatigue. However, we have none for the determination of nervous fatigue. Because of this it will be necessary to pay attention to the study of the questions of higher nervous activity in relation to automation.

Along with the technical conditions there will also be alterations in the mutual relationships between the workers. The cooperations of the collective will acquire new characteristics and the relationships between superiors and subordinates will be changed. Work in the conditions of automated production will make greater demands on the collective and the dependence of the success of one worker in his job on the success of another worker will be increased.

It appears that in automatized production it will be desirable not only to organize and equip each work station properly, but also to see to it that there is a physiologically correct regimen of work and rest throughout the work day and that free time is properly utilized. It will be necessary to guarantee suitable restitution of the functions strained in the performance of work through physiologically directed physical education which can also compensate for the deficiency in muscular movement during work in automatized production.

i. Finally, it is necessary to stress several other problems connected with the introduction of automation. Gradually introduced automation will also demand the elaboration of suitable criteria for the allocation of work forces and for the retraining for other work areas. Also related to this is the question of selection of jobs, not only from the viewpoint of medicine, but also from the standpoint of higher nervous activity and psychology. Automatized production must not be hindered by unsuitable work assignments. All this is also connected with the questions of proper physiological training for new forms of work in mechanized and automatized production. Further, we can presume that in automatized production there will occur several work areas especially suitable for women as well as for persons with altered work capacity. Such places must be medically evaluated and reserved for such personnel.

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C. Summary of the principles that must be followed in mechanized and automatized production processes.

1. Mechanization of Production

a. Mechanization must contribute to the insurance of work climate, correct work performance and to the reduction of errors in work performance. Mechanization must be utilized for the improvement of the hygiene of the work environment, and for the reduction of physically exhausting labors as well as to the greater intensification of the care for the health of the workers in general. This goal can be achieved as follows:

(1) by the reduction of the degree of exposure of the worker in areas of immediate contact with harmful agents, ie., the worker is separated by the mechanized machine from the sources of the harmful factors;

(2) by the reduction of the degree of exposure of the worker to the harmful factor (in the general sense of the word) because the mechanized means will substantially reduce the production and escape of the harmful materials. The exposure of the worker will also be reduced by the reduction in the physical effort involved in his work in the dangerous environment; thus, superloading of the organism by heavy physical labor in a hot environment will be removed and the lung ventilation will be reduced, etc. Mechanization can also reduce the exposure of the worker by reducing the time the worker has to spend in areas of accumulation of harmful factors;

(3) by complete elimination of harmful substances and hygienically defective labor processes through the change in the technological process;

(4) by the decrease in the physical effort primarily in areas where the workers are physically overloaded. From the physiological standpoint the caloric output in the current work week equals, in men, at the most 2000 kilocalories and 1300 kilocalories per shift (above the consumption during rest).

(5) by the reduction of the physical effort in areas and production processes in which it is necessary to employ women or workers with altered work abilities;

(6) by the reduction or elimination of one-sided physical or mental strain and possibly of mental tension;

(7) by the reduction of the danger of accidents and the elimination of other factors in the production process which increase morbidity and invalidity;

(8) by constant and therefore effective protection by health against the action of harmful waste products;

(9) by better insurance of the hygienic standard of the products by the elimination of the immediate contact of the worker with the product, e.g., in food and medical industry;

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(10) by the systematic realization of the principles of esthetics in the construction of the work area and the technical equipment designed to have esthetic effect on the total complex of sense organs involved in the production task.

b. Introduction of mechanization must not be a source of hygienic deficiencies.

(1) Mechanization must not result in worsening of the conditions of the work environment and the mechanization means must not injure the health of the employee at his work area. In cases where the introduction of mechanization would cause a worsening in the hygiene of the work environment, it is necessary to consider the possibility of a total change in the technological process used in the replacement of the harmful material by non-harmful material, etc. (2) Mechanization must not be a source of other harmful effects not seen in the conventional production processes, e.g., it must not cause an increase in vibrations, radiation, searing heat, sound level, etc.

(3) Mechanization must not be a source of effects which would impair the physiologically correct environment in general. It must not impair the high level of socialistic culture, i.e., must not act negatively even on the esthetic needs and demands of the workers.

(4) Mechanization must not cause increase in physical effort, static labor, non-physiologically enforced work speed, one-sided or superfluous load on the sense organs and the individual functions of the organism, non-physiological positions of the body, etc., in the areas from which the mechanization means are controlled and in the production processes connected directly with the mechanized units. It is especially important to remember these principles in the design and construction of mechanized production lines, i.e., it is always necessary to consider the principles of correct work and rest regimen.

(5) Mechanization must not cause hygienic deficiency of the product.

Mechanization must not lead to a worsening of the health situation in the neighborhood of the production unit.

(6) Mechanized equipment must not be controlled by untrained or insufficiently trained personnel because of safety precautions and labor hygiene.

(7) Mechanized equipment must be operated by properly allocated workers from the standpoint of somatic and psychological selection.

(8) In areas where physiological principles had not been considered in the introduction of mechanization, there will necessarily occur a one-sided loading of the workers. In such cases, it is especially necessary to remember the correct work and rest regimen, and the introduction of physiologically justified work breaks.

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(9) Work norm determination in the newly mechanized production processes must not lead to an increase in the intensity of labor over a physiological optimum limit both in the work on the mechanized line and in related processes.

1. Automation of Production

a. Automation of production

(1) will contribute to the speedy reduction in work time;
(2) in automatized production it will be possible to employ personnel of higher ages as well as personnel with altered work capabilities.

(3) automation will contribute to the elimination of harmful effects affecting the workers directly, e.g.,
(a) by the reduction of the physical effort of work and elimination of one-sided overloading of the organism,
(b) by removal of workers from processes involving exposure to detrimental and harmful factors;
(c) automation will contribute to a more effective collection and removal of harmful factors;
(d) finally, it will contribute to the increase in the hygienic standard of the products.

2. Automation could in some areas produce unfavorable effects and therefore it is necessary to consider the following circumstances:

a. Automation must not be the source and origin of new harmful factors affecting the workers in the production process and the inhabitants of the surrounding areas.

b. Automation must not lead to non-physiological loading and overloading of the organism especially in regard to sensory and mental functions. In the areas where there will occur a one-sided loading of the organism in the transitional period, it is necessary to give attention to physiologically suitable allocation of the work tasks, to alternating assignment to work areas, to psychophysiological suitable arrangement of the control and indicator panels and instruments, to the color schemes, to the decoration of the work area and finally, to a suitable reduction in the actual work time. At the same time it is also necessary to remember the correct method of utilization of free time, e.g., to insure the restitution of the functions utilized at work with the aid of physiologically directed physical education.

c. Automation must not cause a worsening of the work conditions in production connected with automatized production, e.g., enforced work speed or worsening in the work environment in non-automatized but related production lines.

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D. Summary

An account is given of the general directives - hygienic, physiological and psychological - concerning mechanization and automation. The health aspect of the mechanization and the automation of production procedures is dealt with in greater detail. In conclusion, there is presented a summary of the principles to be observed in mechanized and automatized production processes.

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